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APPLICATIONS WORKSHOP III-A-4

FLUID DEVICES

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William Gruber (Technar), and Jack Leroy (SL)

ROLAMITE VALVES

William Gruber began the workshop session by describing Technar's use of rolamite as a valve. The mechanism shown in Figure 1 is housed in a fluid-tight enclosure. When the magnet on the left is energized, the rollers are pulled toward it and the band rolls over the outlet port. The pressure within the device then forces the band down against the port and leads to high sealing forces. When the magnet on the right is energized, the cluster moves to the right and a very large mechanical advantage is available to peel the band from the outlet.

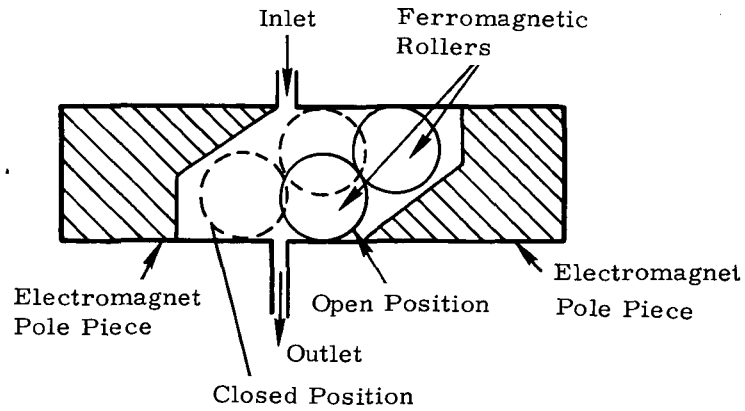


Figure 1. Technar Rolamite Valve

VALVE OPERATING CHARACTERISTICS

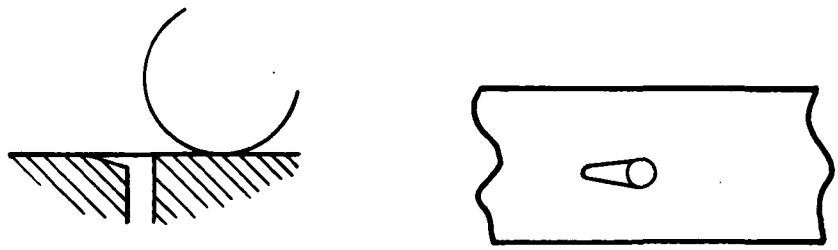
Although Technar has taken no particular precautions to obtain a good seal, they obtained leak rates of 6.5×10^{-4} of maximum flow rate for a 1.6 gpm valve and 2×10^{-4} for a 0.2 gpm valve. The materials were stainless steel bands operating over rollways made of acrylic in the former case and brass in the latter. Water at 80 psig was used in both cases.

GENERAL CHARACTERISTICS

The advantages of such a valve include high sealing forces and low actuating forces coupled with the absence of moving seals in the case of an electromagnetically actuated valve. It seems particularly attractive at the extremes of temperature or in the absence of lubricants.

COANDA EFFECT

An interesting complication arises from the Coanda forces created when the fluid moves past the curved roller surface near the outlet port. The forces are such that the rollers are pulled over the outlet and the device tends to shut itself off. However, by contouring the outlet port as shown in Figure 2 the magnitude of these forces has been reduced substantially.



Side View Top View

Figure 2. Contouring for Coanda Forces

ACTUATION

Problems encountered in valve development include the difficulty of mechanical actuation and the inefficient magnetic circuit. Furthermore, the device operates satisfactorily only with unidirectional flow.

ACTUATING POWER

A jet pipe servo flapper could probably perform the functions of this valve, but the actuating forces are likely to be a good deal larger.

PROPORTIONAL CONTROL

Technar's prototype valves to date have all been on-off devices. It would be possible to make a proportioning valve by contouring the outlet as shown, but then there arise problems of cluster positioning.

FREQUENCY RESPONSE OF VALVE

The maximum operating frequency of the electromagnetic valve is 15 Hz. The band is constructed with an additional leaf at each end which gives the roller cluster an equilibrium position near the middle of its travel. The natural frequency for oscillation about this equilibrium is about 15 Hz.

ROLAMITE FLUID DEVICES

In beginning the discussion of what role rolamite has to play in fluid device technology, H. A. Brunner (Reynolds Metals) commented that rolamite is up against very stiff competition in the pneumatic control field. There is now on the market a spool valve which has extremely close tolerances and requires no lubrication to operate for at least 20 million cycles. The device is immune to contamination because the sharp edges on the spool just grind up the particles. It competes very well with fluidics because it is so reliable.

Chairman Scroop pointed out that rolamite devices would offer much easier manufacture—assuming, of course, that they could perform the same job. He went on, "I would like to ask if anyone has any

thoughts about using rolamite either for an impedance-matching device in fluid circuits or at the interface between fluidic and mechanical elements."

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ACCELEROMETERS

Jack Leroy pointed out that it seems premature to give rolamite a specific role. However, Sandia is pursuing development of fluid-filled rolamites which integrate acceleration to obtain velocity. Leroy described a method Sandia uses to meter fluid: by means of a tube connecting the ends of a closed rolamite channel which contains the fluid to be metered (Figure 3).

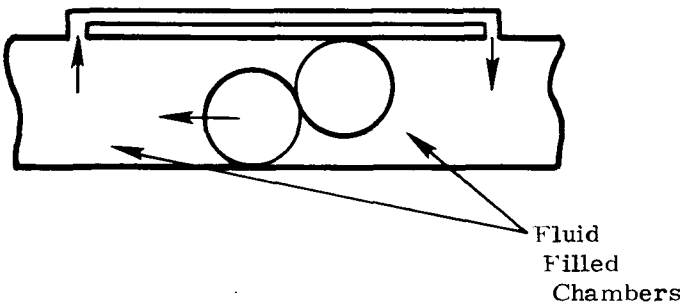

Figure 3. Sandia Fluidic Accelerometer

The application is a missile launch, so g forces are used to actuate the device.

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SIGNAL AMPLIFICATION

General Electric has been doing considerable work in fluidics; one of their problems has been amplifying signals to useful levels in pressure ratio sensors flowing hot gas. One is usually dealing with rather low pressure differentials in the neighborhood of 2 psi or lower. A nearly frictionless device such as rolamite appears attractive as a means of making the transition from the pressure signal to a mechanical output. GE is presently using torsion bars which are difficult to manufacture because of the small forces involved. Although the rolamite principle has not been tried in applications of this kind, it looks feasible and well worth investigating.

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USING INHERENT LOW-FRICTION ADVANTAGES

G. B. Wilkes agreed that if one hopes to use a rolamite, its inherent low friction should be exploited. For example, if one is working with very low pressures, the rolamite could be an attitude functional device whose position depends upon the pressure within a bellows, say, attached to one end. When the pressure achieved a predetermined value, the cluster would move and perform a switching or other signalling function.

PROBLEMS WITH FLUID DEVICES -- END SEALING

When one considers sealing around a rolamite cluster, there are no problems with respect to the lines of contact along the rollers.

Even if the geometry is not particularly tight, tension makes a seal between the band and rollers. The ends of the rollers, however, present a much more formidable sealing problem. In typical applications, the end gaps must be kept below 0.0005 to 0.001 inch for gases and 0.005 to 0.004 inch for water. You can see that some expensive machining is necessary in order to obtain true sidewalls.

TOLERANCES

Wilkes proposed what he felt was the best way of solving the general problem of end sealing. One can make rollers with a slightly beveled end that fit in a channel with beveled sidewalls, as shown in Figure 4.

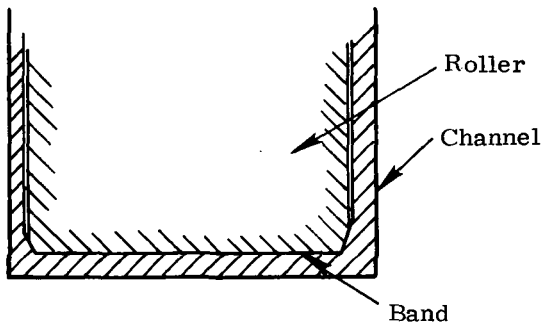

Figure 4. Beveled Sidewalls

This almost eliminates short leakage paths near the points where the rollers are tangent to the channel. In addition, the roller can be spring-loaded to take up any tolerances in the length so that one need only put a bit of quality control into making the angles correctly.

As an example, RTI built a rolamite using an extremely accurate electroformed channel with two tungsten carbide rollers 1/2 inch in diameter and 3/4 inch long. With the end of the channel closed off, it took 7 minutes for the rollers to fall an inch under gravity.

The effects of leakage can be reduced further simply by making the rollers longer. In this way the leakage is kept constant while such things as the swept volume and forces due to pressure gradients across the roller cluster can be made large.

Jack Leroy added that Sandia's approach to end sealing is to minimize the end clearances within the context of efficient manufacture. Then they adjust the viscosity of the oil and the orifice size so that flow past the roller tips is negligible. Tests are under way to define the success of this technique.

SIDEWALL ORIFICE CONSTRUCTION

Minimizing the orifice is related to the means used to prevent the rollers from rubbing on the channel sidewalls. Since initial rolamite work, many have assumed that the best way is to provide angles in the channel. However, Sandia is beginning experiments to determine whether or not oil will keep the rollers from touching the sidewalls so that no angle is required. Obtaining this angle may be the single biggest problem in manufacturing cases, so its elimination could be significant.